

Alexander E. "Sandy" MacDonald, October 2010

Topics: PROFS, AWIPS, NWS Modernization R&D

I'm Alexander Edward MacDonald, and I joined NOAA in 1973. I was getting my Ph.D. at the University of Utah in Meteorology, and I joined their summer program. Len Snellman hired me, and Hazen Vedcue was the regional director. And after I got my Ph.D. in 75 (I was part time 'til then) I was full time in the Scientific Services Division which was headed up by Len Snellman, and worked with a terrific group of people there in western region from 1975 to 1980.

And even then, when I was in Western Region, I heard about this program called PROFS, program for regional and forecasting systems and that program was actually led by Don Barron who worked for Gordon Little at the Environmental Research Labs which were in Boulder, and Gordon Little was the lab director of something called the Wave Propagation Laboratory and I remember Doug Sergeant and actually before that I remember that Don Barron had a kind of a retreat to talk about how, you know, the Weather Service or NOAA could use systems types of approaches of designs, next generations system.

And he had this idea of a local weather system, PROFS and what I really think happened was that Weather Service kind of co-opted the idea, Dick Hallgren was at that retreat in Estes Park and one thing I remember a lot was one evening sitting with Dick, late into the evening in the bar at the Stanley Hotel or wherever we were, it might have been the Stanley I think and Dick talking about, you know, what, where Weather Service was going to go and it was kind of neat because I was in the weather service regional office but here I was rubbing elbows with the director of the weather service talking about what we needed for future weather services.

And I think it's not too surprising because I had been kind of, I think, leading in the Weather Service with the idea that the computer revelation was coming and we needed to get going on it. I actually pushed the idea that we get a mini computer and we actually set it up so that people could use it around the Western Region and we got a training, I got a training program going for some of the Western Region personnel on computers so there was this idea that we were going to have a, it was important to get, you know, these computers into the operations of the Weather Service and I was sitting there with Dick Hallgren and we talked about the future of the Weather Service late at night.

And I think, as I was saying, to some extent weather service, this thing that Don Barron was proposing and Gordon Little as kind of a prototype for the local Weather Service that they wanted. And it's really hard to un-sort how ideas arise but, you know, there's no question that Dick Hallgren was, you know, I think the architect and had this vision of a future Weather Service and he had the kind of political smarts and the connections and everything you need. I think he was a fairly unique individual but one thing I think he did depend a little bit on which, he was good at working with different people.

But I think he was really, you know, with me, discussing how could we do this? How could we take these various data sources like satellites and radars and the old teletypes which brought in station data and you had the old fax machines. So there was data coming in from all kinds of

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different sources and the idea is, could we build an integrated system? And my position with Dick was, I had taken a lot of computer science courses at the University of Utah, and my position was, absolutely and we could build it and that was sort of the brash optimism of having never done these things before but I had a lot of discussions.

So then Doug Sergeant was hired by Dick and the timing on that might have been 1979 and I joined the PROFS program in 1980, pretty much right near its beginning so I moved from Salt Lake City, where the [National Weather Service's] Western Region is over to Boulder and became part of the PROFS program under Don Barron, which was at that time becoming independent from the Wave Propagation Lab and I remember PROFS was funded at 4 million a year which was a big step and I think it was funded partly because the senior people in NOAA, you know, I assume by that time I think Bob White was long gone but the senior people and I should have reviewed the names, I should have had all these names.

I remember at various times earlier in my career talking to a guy by the name of Jack Townsend who was the deputy under secretary equivalent at the time and a lot of the senior people I had kind of met and talked to so as part of PROFS what we were what Don Barron had proposed to do was build one of these things, you know, build a local Weather Service and I think the reason that this thing got funded at 4 million a year in the teeth of the new Reagan administration which was very hard to get money in that particular time, I think part of the reason it got funded was that this was the research side of NOAA saying we want to be relevant to the operational side.

And the operational side under Dick Hallgren was saying, we want that and the head of the Environment Research Lab of NOAA Research at the time was Bill Hess and Bill was I think feeling the same thing. He wanted to make sure that the kind of research that NOAA was doing was relevant. So you had this juxtaposition of people on the Weather Service side who I remember particularly at the beginning was really, 1980 being the beginning, was Doug Sergeant and Dick Hallgren and on the research side was Bill Hess who was the head of Environment Research Labs and Gordon Little who was the head of the Wave Propagation lab and under him was Don Barron.

So you had these five, I think forward looking people saying 'we're going to have research and NOAA operations work together to bring this new capability,' which soon got named System 2 and I think System 2 was kind of the idea that I had cut my teeth working on the AFOS system and that was a system that basically automated kind of a teletype and the fax machine part but it didn't bring in the radar and satellite so AFOS was a system that the Weather Service got going in the 1970's and it really was a Dick Hallgren's first run at trying to modernize the Weather Service. Nowadays when I talk to Dick Hallgren I always say, well there was the first modernization which was, you know, what we now call AWIPS and he says 'don't say that, he says there's actually been like 10 or 20 modernizations in the weather service and you just don't remember them all.'

So I now accept that and to some extent AFOS was the modernizing of the weather service of the 70's and what became AWIP's system 2 being system 2 and AFOS being system 1. That became named AWIPS and I think it was roughly in about 1982 or 1983 that Hallgren, you know, took the name AWIPS 90 for the information system part of it and that was really kind of what

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PROFS was centered on, it was put together this information system but it had come out of Wave Propagation Lab who were very much into radars of various types including ground based profilers to give you winds, surface to 16 kilometers.

And they were actually quite big in Doppler radar in other areas and that's really kind of why Gordon Little was connected to this, saying well, we can help with this and Don Barron was, I think a real visionary in his own right, he was saying we can have all these different types of data put together to really improve local weather services and so I think Don deserves a lot of credit for getting PROFS going and I think it's a credit to all of them for kind of recognizing that we had to work together. So I joined PROFS in 1980, summer of 80, and it was very exciting time because here you have a threshold of all these different technologies, radar, satellite and the weather service modernization which in a few years became known as the modernization and restructuring where the restructuring is really changing our field structure.

So that particular time was, how can we do this? How can we really improve weather services? Now there was a strategy of Hallgren's that essentially said, well, we can see that weather services can be supplied partially by our commercial sector, but the part that really does belong to the government is the public safety part. So he said, really we've got to make sure that what we've learned in these Doppler radar tests like the, what's it called? The sesame experiment? I can't remember but there was that, no, it was JDOP Joint Doppler project and they had set up the Doppler radars in 1979 and there was a big tornado that hit Wichita Falls, Texas, I think Joe Friday was involved from the Air Force side and there were a number of other people and they had a really a good signature of that storm.

They could see it on the Doppler. So one element of thinking about this was that Doppler radar gives you knowledge of the most severe storms, the super cells and even, we ultimately came to see the tornado vortex could be seen by the Doppler. And so this was one element and a second element in my mind that was important was, and is part of the driver in my opinion, was the big Thompson flash flood which I believe was July 31, 1976. It was not handled very well by the National Weather Service. Their radar was a long way away from that storm and people can always second guess forecasts, I've been a forecaster so I know how hard it is. But that was a devastating event that killed on the order of 140 people and the warnings probably could have been better.

So you had this drivers that essentially say, 'boy, we think we can do much better on tornadoes and flash flood, these convective events' and you have a leader like Dick Hallgren who essentially said 'we need to put all of our new technologies, particularly satellite and radar and so on, surface stations and so on together in a system that will improve our weather warnings.' And that was, you know, fit well with this conception of PROFS and I think the conception of PROFS partly had to do with the fact that those people there in Boulder, in Environment Research Lab were pretty close geographically to this terrible event of the death of 140 people and the incredible power of the big Thompson flash flood.

So you had this coming together of two parts of NOAA, one of them is the research part saying, 'we want to help you build this' and one is the operational part where you have a visionary and leader like Dick Hallgren who knows the system and says, 'I want to build a National Weather

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Service that is modernized and uses all the data in the right way and what I expect to get out of this is a big improvement in our ability to put out weather warnings.' And nobody can argue with that. That's clearly a government function, protect the people.

That's the first function of government. So that was the setting that we went to work. And my own contribution, I think, was a couple things. One of them was that I had this conception of how we could put together the various data into an integrated system and I felt I really led on that. I had people working for me and I probably didn't publish as much as I should have, but it was really my conception. On the wall in the room here is a picture of AWIPS because I regard that as one of my creations that I had some kind of creative and initial input and that is how you put together a integrated system that had the satellite and radar, you could see them together, you could interact with them, you could watch them in motion.

In all the things that I had wanted as a forecaster, and I'll just mention parenthetically that I'd been an Air Force Weather forecaster for three years, actually doing the forecast day in and day out so I had, what I felt, was a really good understanding on how a forecaster works and thinks and the kind of tools they need. So I wasn't just a guy with a PhD who knew something about computers. I also had been a forecaster. And I stayed in the Reserves and kept my hand in forecasting and working for Len Snellman had gone out to almost every darn office in the Weather Service and sat and talked with them about how they do their jobs. So I really did bring a Weather Service and weather forecaster viewpoint into the job in the research side of NOAA.

I think, again, that what I found in the research side of NOAA was a really refreshing ability to try new ideas, and that's what you'd hope out of your research side and that's exactly what I got. People always gripe about management but I remember senior people like Bill Hess and Dick Hallgren and others saying 'Well Sandy, what do you need for this?' wWell we need, you know, this kind of fax computer or we need that kind of these expensive color displays' and people would say, 'color displays?'

'You know, do you really need colored displays that can give you motion?' And I said, absolutely. We need those things. and of course that's being a little short hand but I do remember that Don Barron, I said to Don Barron, I need these kinds of computer scientists and these kind of meteorology. I remember Don being very supportive. So I worked with a team of people, you tend to mention the same names but there were a lot of people like Ron Alberti, Duane Haugen and people from NCAR like Bob Serafin and John McCarthy and others.

We worked a deal so we could get the NCAR radar as part of our system. I kind of started with a philosophy that probably both Don and I and others, but it was sort of the philosophy was, I think the part that I might have said, Don said, yeah we got to have radar and everything and let's do it. Maybe the part that I had something to do with was, 'saying we're going to use, I don't think it was even called this, but I think we're going to use rapid prototyping. We're going to build a version of this system that, even in the first year it really is pretty limited and it isn't anything like what we ultimately want.

We're going to actually get software people and build one. Nowadays that's called rapid prototyping and I think it's the absolute key to the fact that we really progressed pretty fast. So

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by the summer of 1981 we had a system that a lot of people thought was fairly impressive. It had the satellite and radar and had things on it. We learned a lot from that and we said, 'okay, we're going to start again from ground zero and build another one' so we built the 82 system. And we built the 83 system. By the time we built the 83 system we had television crews coming from Washington and New York to show this advanced system that we were working on.

For me it was, I was enabled by the fact that we had budget, by the fact that we were being asked to do this by these discussions. I was enabled to hire the people and start to really building the forecast office of the future. Now I want to stop and mention a particular management entity that Don Barron started and that I continued because I became Director of PROFS in 1982. Don went on to lead the profiler network program, and it was called the Troika and the idea was that if you were going to modernize the National Weather Service it had to be the head of the research service, or Environment Research Lab at the time, it had to include the head of the National Weather Service and it had to include the head of the satellite service.

In the old, old days, I can't remember exactly when these people changed. I think there was Dave Johnson originally and then there was Tom Pike for a good portion of the 80's and from NESDIS. We would have these meetings, two three times a year, I think actually three times a year was probably the average and it would be the AA's. either somewhere, either in Washington or in Boulder. Meeting to talk about how we were going to modernize the weather service. it wasn't long into it then Lou Boezi got involved and I'm trying to think of other people that contributed a great deal. But for me the person that I really worked closely with was Doug Sergeant. Doug was, like everybody, I think one of the people in my career that I think was very important and important because he was so, I think, he was so strategic.

He figured things out and he analyzed them in a lot of detail. Doug and I would talk, literally for hours and hours. I'd come to DC and we'd have dinner. I can remember getting thrown out of a restaurant at midnight when they closed and we might have talked maybe for 8 hours. And the discussion was all essentially, 'how can we make this really complex thing of the modernization and restructure and how can we make it work?' There's a lot to it, that's where I think now I look for those same things. Who are the people who are really thinking out every aspect of this? If you don't have that, I think if you simply think, 'well all we have to do is put out a contract and industry will know how to build this.' I think you can get in pretty deep trouble.

And without going too far into detail I see some of these big programs with cost overruns and difficulties and I'm not just talking about the biggest ones, but I'm also talking about a lot of the middle size ones that I see occurring in NOAA and other places like the FAA and so on. They really have to have a thorough deep understanding of the technology and the people and the OPS concept and the political environment. It's not something that you can just sort of come in and say 'well, I really know how to do this and what you mean is maybe you know how to do the computer part but that isn't the thing.'

It's sort of like somebody coming in and saying, 'I know how to build an auto and what they mean is, they know how to build an engine.' But an auto has got a drive train, it's got the passenger compartment and it's just got a complex system that you put together and when you think about the modernization and restructuring of the Weather Service. So there was this

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connection between the research side, which I had moved over to and the Weather Service that I came from but the leadership of the Weather Service who were really depending on the research side. now it's important that I mention that there was this whole other stream, extremely important, that I was involved with a little bit.

That is the radar stream. So National Severe Storms Lab has a long and illustrious history back into the 60's. when I first came to Boulder for a meeting called 'Open Sesame' in the summer of 1972, it might have been, I met the lab director of National Severe Storms Lab who is Ed Kessler. And Ed Kessler is a fascinating person, but Ed was supportive in National Severe Storms Lab of the Doppler radar developments that occurred so when you think of things like the Joint Doppler experiment in 1979, obviously Ed had played a role in getting them there. But what I would say with regard to NSSL is that they were a real leader in the Doppler radar and the lead in from a Doppler radar that was built around research to the program called NEXRAD which delivered the operational Doppler radar network.

And there are those that would say, 'oh what happened when the modernization and we've got the modernization running and they've improved the severe weather warnings.' And I think that's part of the story but I think this other part of the story is setting up the field structure, getting the information system, namely AWIPS. So when we were developing these so called PROFS work stations we couldn't really use the Norman [Oklahoma] radar. Down in Oklahoma we had to work with NCAR and get a radar that was right there in the Boulder area and we set up a satellite ingest system and we had all the other stuff and we would put these together in this information system. AND here's a real key. This rapid prototyping, we took it all the way to bringing in National weather Service forecasters into NOAA Research test bed, namely PROFS, and actually having them operate like they were in their forecast office, the only difference being that they weren't really putting out warnings for the public.

They were putting out warnings using a new advanced system. I think that what we got out of that, and this is now fuzzy and got to be careful to adhere to the facts as well as we can, but what I remember is that we were pretty careful about measuring and doing controlled experiments with these forecaster, and I remember we got something like a 30 points better on the critical success index and, you know, better lead time and a better critical success index. When, and that was the tests that were conducted, particularly the 83 test, now I was thinking, well we can really get decrease our false alarms and increase our probability of detection enough that we should get a significant improvement and we roughly thought that that was this index called the Critical Success Index would lead to a very significant saving of lives.

When we got the whole system running, we got AWIPS running in 97, 98,99 and 2000. Joe Friday [NWS Director at the time] went around to the forecast offices and the improvements in probability of detection and false alarm ratio that we had seen in the 1983 test were very close to what happened in the offices. And those improvements were big improvements. The public was essentially getting something that had been tested 15 years before. Sad that it took 15 years but it was a tough slog. And now and ever since I think people rightly so, have a much better weather warnings and it's because of this. I think coming together of the Weather Service and the research side. So that was kind of the early part. That was kind of the 1980's part of the modernization.

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I want to talk a little bit about the 90's part because there's some interesting lessons there and I think to do this justice I'd have to talk for five days straight and Barry looks a little tired to me. But there is this other thing that we find.

Which is, and it's really difficult to go through a process of putting out a big system. So this is the Modernized Weather Service. We're going to put out radars, we're going to change the field structure of the National Weather Service from 230 offices to 130, kind of think of them as super offices. Dick Hallgren had these various conceptions which really are core and I remember I talked about him as one of the great strategic thinkers. He'd say, this goes all the way back to, I always describe everything as, Dick and I figured that out at that late night, drinking Scotch at the Stanley Hotel. You can almost see Jack Nicholson watching us.

So we're sitting there and he would say things like, 'well you really need the system to be kind of the size that you can cover with the radar system. You know, you've got the radar, you get that excellent radar coverage, that's also as far as a maintenance person can drive out and drive back and so you have the warning areas corresponding to the area covered by radar and you staff it completely with professional meteorologists, you have everybody degreed' and so there were all these concepts that went into it and I want to say that I think that I keep talking about Dick but I know Dick and Lou Boezi and people that, I can't lay my, I can't recall this one name but I remember this one guy.

And he would talk about things and I'd get invited several times into Dick's office late in the evening, 7 or 8 o'clock and they'd be sitting there talking about these things and Doug Sergeant was often in on these conversations and really I remember Doug kind of going through this. 'Well the new restructuring, one office, about the area that they can really cover with the radar and so on, so all these conceptions that are now kind of in people's mind but what the Weather Service is are there. And then there's these really core concepts which is Dick feeling very strongly that, you know, it's a service. This service has to be based on knowledge that person, that the forecaster understands what the needs of this local area. The forecast problem changes all the time. It changes and it's different and it's different for different places.

In the west now, the forecasters are really facing this red flag warnings in these forest fires and they understand that when you've had like three or four days of relative humidity down in the single digits and you get winds, it's almost like spontaneous combustion. Well this is what Dick's idea comes to convective weather and local understanding and the ability to know what the local problem is. You want that forecaster there 24/7, really oriented toward what the problems are and understanding the local weather like nobody else can. That combination to me is the heart and soul of the modern Weather Service. It really is and we've made progress since. The modernization is to some extent, got a little bit of separation from the great progress that we've seen world wide in our modeling and our faster computers and so on so that's a little bit of a different theme.

But, those products that I've seen this last few years, I get a lot of satisfaction because you see the Denver snow storms over the last five years, they've mostly nailed them two and three days in advance. There was three big snow storms in Washington [DC] this last winter and they

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nailed them. you're telling people, you're going to get two feet of snow three days from now and this last set in Denver, and this last set in the East and you're seeing it everywhere. They're basically shutting down the aviation operations. And so on. An incredible value.

And you look at what we've seen in hurricane prediction which is over 40 years, going from average error of three days of 400 miles to average error of now 80 miles. That's a little bit of a different theme from the modernization. Although we certainly talked about those a lot and did a lot. That was one area where I always kept insisting, well we're the research side and we're going to do modeling and Dick was kind of saying, 'I think we already have enough modeling around' but we kind of stuck with that.

So maybe back to a summary of the modernization and the role of the research side. I don't think it could have been done, I really don't think it could have been done without a partnership and the partnership was partially based on the personalities.

The personality of Bill Hess and Gordon Little and Dick Hallgren and Doug Sergeant. I think it was partially based on that, but it is a real lesson and that is that the research side has to be free enough to create new things. The operational side always wants to say, well, all we need is a little improvement on what we do now and we used to always kid and say, they just want somebody to sweep the floors and we want to create a giant new Taj Mahal as sort of the extreme versions of that. The operational side, I think needs the research side to have a vision of new things and we even see that today. I think we have a vision of what the weather service could be in 2025 and 2030. I really believe that the kind of people that you get into a research organization, they talk to each other and you really get a different flavor and I know that because I've spent 15 years of my career in the operational side. I've seen it.

So you really need the research side with ideas and talent to build these things. You need the operational side to have the vision to say we want to do this and we're going to work with our partners to do it.

So that's what happened in the modernization. I regard it as a huge success, you know, a great privilege for me to work with all the people I mentioned. I remember it was tough every month and every year was tough. There was always 'how can we get the system built.' In the '90s, we were trying to get the contract through and I think that it's hard to have the commercial contractors have the depth of knowledge that you need to build these really technical system.

And in my opinion, it only works if you have a real in-depth knowledge and that in-depth knowledge of the modernization, the radars and the information systems and so on. That was supplied a lot by NOAA Research, and I think it has to be that way in the future. Anybody that thinks all you've got to do is put out a contract, I think you're going to get a nasty surprise and we see plenty of those. So I think that's a key and it's something that's going to be true forever. I always say if you want to get taken to the cleaners walk into some commercial organization and say, "You know, I know what I want but I don't really know much about it, what can you sell me?"

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I think you're going to get taken to the cleaners. So within NOAA we know we can make it work. I hope we can do that in the future and I hope that this little short discussion is helpful.

Barry Reichenbaugh: Well, my job's been easy so far. I do want to at least cover one thing that you touched just a little bit on. You talked about when you first were getting the early PROFS systems going, that you had media coming from New York, from Washington. Can you talk a little bit about how you changed some people's minds from Capitol Hill? Now I know you had visitors come out to Boulder and then they may have had something in their mind that this didn't really need to continue to be funded. And Carl Bullock talked a little bit about it, but I'd like to hear your perspective on it.

A. MacDonald: It's a great question, Barry, and I should have mentioned that. There's an interesting thing about rapid prototyping approach, because if you write words on paper 'we're going to build this or we're going to build that.' They really don't impact people. People are visual. You have to really understand that. So... we built the 81 system. It really wasn't much to brag about. It was, you know, it was really limited. But by the time the 82 system, we actually had a touch screen and it was things that people hadn't seen with all these kind of moving images of radar and satellite. Nowadays they're on everywhere all the time.

In those days nobody else was doing that! This was new. And so let's see, I'm just going to ignore that I guess. So what happened was we would bring out people from Washington. It wasn't just Capitol Hill, but it was definitely Staffers, and the one I really remember was Scott Gudes. So they would come out and they had heard about this program. It's the Reagan Administration, budgets are really tight, and this wasn't selling, us doing this research, this was really basically saying I think Hallgren knows what he's doing.

Weather Service has got a running version of this, and so an advantage of rapid prototyping, you know, the first advantage is you can actually build really complicated, wonderful things if you're willing to look stupid at the beginning. So that's how you build really new things like moon rockets and everything else, is you go build it. But there was this other things, which is we had to have the proof that these ideas actually worked, so people would come from Academy study groups, like Bob Serafin, or they'd come from Capitol Hill like Scott Gudes, and Congressmen and journalists and so on.

And they'd come out and they'd actually see forecasters testing out these systems, and that was really key. I don't think if we had – if we didn't have that I don't think the whole thing would have ever come to fruition. And I do feel that that was a vision of mine when I started pushing the rapid prototyping. And I want to say actually the rapid prototyping and having these tests and so on, those were a lot of the things that I had pushed because I felt that was the way to get this done.

And not everybody agreed with me on that. I like to maybe not say – talk about all the battles, but that was one where I think is a big lesson for right to today. If you want to do something, build it. Show you can do it and I really think National Weather Service is I think starting to think about what's our big improvements of the coming decade or two, and I think there's a lot to learn there.

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Barry Reichenbaugh: You mentioned Scott Gude's visit. Can you recall just what took place there?

A. MacDonald: Oh, absolutely. I remember that visit really well, and partly because to me – I better be careful because Scott might listen to this, but to me at the time Scott was just another Congressional staffer coming out, but I do remember this, and Scott's mentioned it to me several times. Scott and I sat and talked a long time, and he was typical Scott. Really interested and trying to understand all this and he'd ask a question and we'd walk in there and I'd show him how the computer does this and how we do that.

So a real key is that you have to have people in the system, and they show up in funny places. Scott was a Congressional staffer, but he was a crucial one and I think after that whole whatever it was, three hours, that we talked, three or four hours, he was always a supporter after that. And there's a lot of cases like that, it wasn't just Scott. But it's people who come out. They may be thinking 'we can't afford this. This is government out of control and we've got to stop this \$4 million [Ed. Note: billion is the correct reference] modernization but they could see that it was there and it worked. So that was key. But I remember Scott just sitting and talking and asking questions and can you really do this? "Yeah, look at it. Look at what we've done."

Barry Reichenbaugh: Carl, again when we were talking he mentioned McIDAS a few times, and I'm wondering if you could talk just a little bit about how that compared fit in to all this.

A. MacDonald: That's a really good point. Carl and I worked together in the Western region, and I remember Carl coming back from a stint, I can't remember why he was there, but he was at the University of Wisconsin. He was talking about McIDAS, and I think McIDAS was really the academic lead-in that showed me and a lot of people that you could have kind of these computerized information systems work.

And I remember going to Wisconsin in probably '79 or '80, it might have been '80, and the people there at Wisconsin, and I can't remember who was there at that time. It might have included Andy Edmond, I'm not sure. But I can remember them showing me McIDAS and going through all these things, and me thinking there's some terrific things about this. It's really great for satellite data, but it doesn't have the radar data the way I would want it, because I want everything on the same coordinate system.

And I remember sort of arguing philosophically with some of their developers who said, 'No the natural coordinate system is the satellite system and that's what nature has created.' And I said, 'No. A natural system for me is a nice Lambert Conformal with everything on there exactly the way you want.' So I'm just saying that they were hugely interested in showing this kind of thing, it could be done, but I think we sort of designed our system so it was integrating all the different types. And really there were more subtle and deeper differences. Ours was really designed for a forecaster.

A forecaster, it has to be fast. And actually that was something that was really hard for universities and even commercial companies to understand is that to this day they build a system

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and they don't realize a forecaster can go through huge amounts of information if the system is really responsive and fast, and that's what they want to do. Somehow they think well complete flexibility is it, but it's actually a lot more speed. You kind of build it, define it so it works.

So there was a lot of design issues, but key point, Vern Suomi, the Wisconsin people, they led the way in showing that this kind of thing could be done, and I remember several meetings with Vern Soume [ph] and same impression as everybody else as what a privilege to meet such a person.

Barry Reichenbaugh: Doug talked about him several times during his interview too.

A. MacDonald: No, it's wonderful, wonderful man.

Interviewer: All right. Let's stop there. Thanks.

A. MacDonald: All right.